DETROIT DIESEL'S LOW EMISSION HIGH EFFICIENCY ENGINE TECHNOLOGY

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ABSTRACT

This abstract describes the low emission 55% thermal efficiency (LE55) overview and status progress. The LE55 program goal is to develop advanced heavy duty, on-highway diesel engine technology. This paper describes the Detroit Diesel Corporation's (DDC) LE55 design, preliminary test results and plans. Program results for the 1995-'96 timeframe are emphasized. The LE55 concept design redefines the combustion system, cylinder head, cylinder kit, valve train and charge air system. Engine cycle simulation and finite element analysis guided each system design. Critical systems were subjected to accelerated probe testing in a single cylinder test mode without impacting the start of LE55 proof of concept engine (LE55 POC) multi-cylinder assembly and testing.

The initial single cylinder probe test emphasized motoring of the LE55 cylinder kit and compression seal at rated speed. During the test, peak cylinder pressures reached the design level (230 bar). This operation mode increased piston pin mechanical loading relative to design loading conditions, while reducing lubricating oil flow through the bearing. Thermal loading on the cylinder kit was increased by eliminating cooling water flow to the cylinder. Following the test the compression seal was in excellent condition. The test results guided cylinder kit design modification.

The next test sequence was a single cylinder firing test. This test installed one LE55 POC modified cylinder kit, compression seal, injection system and cylinder head assembly as a single cylinder of the prototype engine test bed. A 40 hour durability cycle was run, including operation at a BMEP of 26 bar, 12% over the rated design point. The prototype engine air system could not supply compressor air pressure at the level specified by the LE55 design. Thus air/fuel ratios were low and in-cylinder thermal loading increased relative to the original LE55 POC design criteria.

The test was completed without incident. Post test part inspection showed compression seal and overall engine parts in good condition. Cylinder kit design

modifications were identified to enhance durability.

These single cylinder tests allowed LE55 concepts to be tested in both a severe motoring probe test as well as a multi-cylinder environment while still in the design stage. This test strategy enabled completion of two cylinder kit design iterations before multi-cylinder LE55 engine parts were assembled.

Multi-cylinder LE55 testing has concentrated at 12 part load points between 1200 and 1800 rpm and 5 bar to 14 bar BMEP. Following engine run-in and 26 hours of engine testing a head gasket failure occurred in one cylinder, ending the test sequence.

The failure was traced to high cycle mechanical fatigue of the liner adapter caused by improper assembly. Subsequent investigation showed the remaining compression seals and cylinder kits in good condition. This test identified an improvement to the LE55 POC assembly procedure.

Upon rebuilding the engine, digitized pressure data was recorded at each part load condition to assess performance of the current engine configuration. Test results indicate unacceptably low air/fuel ratios for the LE55 POC, requiring a rematch of the turbocharger.

The test phase has demonstrated the LE55 concept as viable under the design mechanical and thermal loads. Engine development is progressing in a systematic manner. Further testing will address combustion and emission issues.

Advanced combustion system development using KIVA computational fluid dynamics (CFD) modeling predicted that the DDC domed combustion chamber benefits from increased air utilization and subsequently increased mixing rates. Combustion simulation predicts shorter combustion duration and improved emission tradeoffs at rated speed

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